PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
BRE/337		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/EP 99/ 07957	20/10/1999	26/10/1998
Applicant		
MARPOSS SOCIETA PER AZIONI et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readble form.

[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

[ ] the text is approved as submitted by the applicant.

[X] the text has been established by this Authority to read as follows:

LINEAR INDUCTIVE TRANSDUCER

5. With regard to the **abstract,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

[X] as suggested by the applicant.

[ ] because the applicant failed to suggest a figure.

[ ] because this figure better characterizes the invention.

[ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
P[redacted]P 99/07957

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01D5/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 678 991 A (SCHMIDT SAMUEL) 7 July 1987 (1987-07-07) column 3, line 30 -column 4, line 63; figures 1,2	1,2
A		4,6,8,9
Y	GB 1 433 402 A (HORE D L) 28 April 1976 (1976-04-28) page 3, line 16 - line 61; figure 5C	1,2
A		4,6,8,9
A	FR 2 466 620 A (BOSCH GMBH ROBERT) 10 April 1981 (1981-04-10) the whole document	1,8

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 February 2000	09/02/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Chapple, I

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
[redacted]EP 99/07957

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4678991 A	07-07-1987	NONE	
GB 1433402 A	28-04-1976	NONE	
FR 2466620 A	10-04-1981	DE 2940018 A	16-04-1981
		GB 2061531 A,B	13-05-1981
		JP 56060304 A	25-05-1981
		US 4358762 A	09-11-1982

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 27 June 2000 (27.06.00)	
International application No. PCT/EP99/07957	**Applicant's or agent's file reference** BRE/337
International filing date (day/month/year) 20 October 1999 (20.10.99)	**Priority date** (day/month/year) 26 October 1998 (26.10.98)
Applicant DONDI, Valerio	

1. The designated Office is hereby notified of its election made:

   [X] in the demand filed with the International Preliminary Examining Authority on:
   15 May 2000 (15.05.00)

   [ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was
   [ ] was not

   made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer
Olivia RANAIVOJAONA

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

3

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
BRE/337		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP99/07957	20/10/1999	26/10/1998
International Patent Classification (IPC) or national classification and IPC		
G01D5/20		
Applicant		
MARPOSS SOCIETA PER AZIONI et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 6 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
15/05/2000	02.02.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Grand, J-Y Telephone No. +49 89 2399 2472

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP99/07957

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

2,3,5-11	as originally filed			
1,4,4a	as received on	03/11/2000	with letter of	02/11/2000

Claims, No.:

8 (part),9-14	as originally filed			
1-7,8 (part)	as received on	03/11/2000	with letter of	02/11/2000

Drawings, sheets:

1/5-5/5	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☐ the claims, Nos.:
   ☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)
   see separate sheet

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	2-10, 12-14
	No:	Claims	1, 11
Inventive step (IS)	Yes:	Claims	
	No:	Claims	2-10, 12-14
Industrial applicability (IA)	Yes:	Claims	1-14
	No:	Claims	

2. Citations and explanations
   see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item I

Basis of the report.

The following amendments of the independent apparatus **claims 1 and 8** filed with the letter of 02.11.2000 introduce subject-matter which extends beyond the content of the application as originally filed, contrary to Article 34(2)(b) PCT.

It is not allowable to add originally undisclosed equivalents by using wider technical terms in place of single technical means originally disclosed. Moreover, it is insufficient for the generalization of a feature to have only formal support in the application as filed. If, for example, the application as filed only describes specific embodiments, and the feature's general applicability is not evident to the skilled person, then generalization can not be allowed.

The amendments concerned are the following;

- "a pair of mutually connected secondary windings" in the new independent **claims 1 and 8** are considered to go beyond the disclosure as originally filed.

The expression "mutually connected" in the field of electromagnetics is used to define a device designed to produce a mutual inductance of two components, e.g. wire coils, one in each of two separate but closely located circuits, each may induce in the other an electromotive force for a given current change.

The **claims 1 and 8**, as amended, implicitly includes these features which were not envisaged by the original disclosure and therefore represents an extension of the subject-matter beyond the content of the application as filed.

The specification as filed (see the drawings and the description) defines precisely "a pair of secondary windings connected together in series opposition", see also the figure 1, but not "a pair of mutually connected secondary windings".

Therefore, this feature is generalization which is not disclosed in the application as originally filed.

Therefore, the application is being pursued on the basis of the set of **claims 1 and 8** as if the amendments cited above had not been made, since they are considered to go beyond the disclosure as originally filed.

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement.

Reference is made to the following documents:

D1 = US-A-4 358 762

D2 = GB-A-1 433 402
D3 = US-A-4 678 991

The document D1 was not cited in the international search report. A copy of the document is appended hereto.

1. Lack of novelty
The present application does not meet the requirements of Article 33(1) PCT, because the subject-matter of the following claims is not new in the sense of Article 33(2) PCT.

Independent apparatus claim 1
The document D1 discloses a linear inductive transducer (see title and abstract); including
- electric windings (see abstract);
- a primary winding (see "primary winding (11)" in fig. 1);
- a pair of secondary windings (see "mutually connected secondary windings (13,14)" in fig. 1);
- a magnetic core (see col. 1, l. 5-23 and (20) and (21)), for performing linear displacements relative to the electric windings;
- a pair of input terminals (see "U_1" and "U_2" in fig. 1) electrically connected to the primary winding and adapted for being electrically connected to a power supply unit (see "operating voltage U_B" in fig. 1);
- at least an output terminal electrically connected to the electric windings (see "U_A" in fig. 1);
- the transducer being adapted for providing, through the output terminal, an electric signal indicative of the mutual position between the electrical windings and the magnetic core (see col. 2, l. 44 - col. 3, l. 5 and col. 2, l. 39-43 and fig. 3); wherein
- the electric windings include a second primary winding between the primary winding and an input terminal of the pair (see "primary windings (12)"), the primary windings being electrically connected to each other (both "primary windings (11) and (12)" are in electrical interaction due to the electromotive force induced by "primary winding (11)" into "primary winding (12)" and as such provides an electrical connection, see fig. 1) and to the pair of secondary windings (see the electrical connection between "primary winding (11)" and "secondary winding (13)" in fig. 1), the electric signal including a first and a second component, indicative of the mutual position between the magnetic core

and the primary windings and the secondary windings respectively (see "primary windings (11) and (12), fig. 1 and "voltage U_A").
Thus the document D1 discloses an apparatus comprising all the features of the independent apparatus **claim 1**.

Dependent claim 11
The features of **claim 11** are known from the document D1 (see discussion above).

2. Lack of inventive step
The present application does not meet the requirements of Article 33(1) PCT, because the subject-matter of the following claims does not involve an inventive step in the sense of Article 33(3) PCT.

Independent apparatus claim 8
The closest prior art is given by the apparatus of D1 (see also the paragraph 1 above).
The independent apparatus **claim 8** is distinguished therefrom in that the primary and the second primary windings are mutually connected in series at a connection point, and the output terminals include 3 output terminals electrically connected to the ends of the pair of secondary windings and to the connection point between the primary windings, and the transducer is adapted for selectively providing the electrical signal at one or a pair of the 3 output terminals.
The use of 3 output terminals aims at providing a single structure which makes it possible to attain differential transducers of different types (e.g. LVDT or HBT).
However, the use of inductive transducers of both types is known (see also the page 2 of the description) and the idea of using redundant electric connections and output terminals in order to adapt the same device to different requirements is generally known in the art, see also the multipurpose metres sold in all supermarkets which are instruments used as voltmeter, ammeter or ohmmeter according to the electric connections and output terminals chosen for the purpose of the measurement.
It would therefore be obvious for the skilled person to consider the possibility of using the adequate number of connections and output terminals if the skilled person would like to provide a linear inductive transducer that can present the functional characteristics of a differential transformer transducer, or a HBT, or a LVDT by carrying out simple modifications of connections of output terminals.
Thus the subject-matter of the independent apparatus **claim 8** does not involve an

inventive step.

Dependent claim 2
The features "the primary winding and the secondary winding are mutually connected in series at a connection point, the secondary windings being electrically connected to the connection point" are known from the document D2 (see fig. 5(c)).

Dependent claim 3
The features "each of the primary winding and second primary winding provides a signal that is variable as the mutual position between the primary winding or second primary winding and the magnetic core varies, the first component of the electric signal being proportional to the difference between the signals provided by the primary windings" are known from the document D2 (see fig. 5(c) and 5(d)).

Dependent claims 4 and 9
The feature "the secondary windings are mutually connected in phase opposition" is known from each of the documents D2 (see claim 5) and D3 (see col. 1, l. 33-45).

Dependent claim 5
The features "each of the secondary windings provides an induced signal that is variable as the mutual position between the electric windings and the magnetic core varies, the second component of the electric signal being proportional to the difference between the induced signal" are known from each of the documents D2 (see fig. 5(c) and 5(d)) and D3 (see fig. 1).

Dependent claims 6, 7, 10, 12, 13 and 14
In these claims a slight constructional change in the device of claim 1 is defined which comes within the scope of the customary practice followed by persons skilled in the art, especially as the advantages thus achieved can readily be foreseen. Consequently, the subject-matter of these claims also lacks an inventive step.

Re Item VIII
Certain observations on the international application.
i) Although claims 1 and 8 have been drafted as separate independent claims, they appear to relate effectively to the same subject-matter and to differ from each other

only with regard to the definition of the subject-matter for which protection is sought and in respect of the terminology used for the features of that subject-matter. The aforementioned claims therefore lack conciseness (Art. 6 PCT).

DESCRIPTION

«LINEAR INDUCTIVE TRANSDUCERS»

Technical Field

The present invention relates to a linear inductive transducer including electric windings with a primary winding and a pair of mutually connected secondary windings, a magnetic core, for performing linear displacements relative to the electric windings, a pair of input terminals electrically connected to the primary winding and adapted for being electrically connected to a power supply unit, at least an output terminal electrically connected to the electric windings, the transducer being adapted for providing, through the output terminal, an electric signal indicative of the mutual position between the electric windings and the magnetic core.

The invention also relates to a linear inductive transducer including electric windings with a primary winding and a pair of mutually connected secondary windings, a magnetic core, for performing linear displacements relative to the electric windings, a pair of input terminals electrically connected to the primary winding and adapted for being electrically connected to a power supply unit, and output terminals electrically connected to the electric windings, the transducer being adapted for providing, through at least one of the output terminals, an electric signal indicative of the mutual position between the electric windings and the magnetic core.

Background Art

Transducers with these characteristics, in particular of the Linear Variable Differential Transformer (LVDT) type have been known for a long time and utilized, among other things, in many measuring apparatuses for providing

transducer's core and windings) that is known and generally differs from one, it can be advantageous to define the transducer sensitivity in order to take into account this known ratio, in this way simplifying the processings performed by the conditioning circuit.

Other transducers having particular features are shown and described in U.S. Patents Nos. 4,358,762 and 4,678,991.

US-A-4,358,762 discloses an inductive displacement transducer, particularly suitable for indicating the displacement of the fuel injection control rod in an internal combustion engine, including a variable inductor portion, with two measuring windings magnetically coupled to each other, a comparison inductor portion, with two magnetically coupled comparison windings, and two short-circuit rings. One of such rings is integrally movable with the rod, the displacements of which have to be measured, and cause variations in the inductance of the two measuring windings. The inductance of the comparison windings has a fixed (adjustable) value that depends on the (adjustable) position of the other short-circuit ring. The output of an evaluation circuit is a voltage proportional to the ratio between the variable inductance of the measuring windings and the fixed inductance of the comparison windings.

US-A-4,678,991 discloses an inductive displacement transducer, e.g. of the LVDT kind, including a single primary winding, two series opposed secondary windings, connected to the primary winding, and a magnetic core, linearly movable between the primary and the secondary windings. The particular connection of the (single) primary to the secondary windings allows to get an output signal, between one terminal of the primary winding and the terminal of the secondary windings not connected to the primary winding, that is unipolar, thus rendering suitable the transducer to particular applications such as in avionic or electronic engine control equipment.

Disclosure of Invention

An object of the present invention is to provide a linear inductive transducer that overcomes the disadvantages of the known transducers and, more specifically, enables to define its sensitivity regardless of the geometric characteristics, and none the less ensures a lower output impedance value and a lesser number of external electric connections with respect to the known differential transformer transducers.

This and other objects and advantages are achieved by a transducer according to claim 1.

A further object of the invention is to provide a linear inductive transducer that can present the functional characteristics of a differential transformer transducer, or a half bridge transducer, or a transducer of another type, by carrying out simple and rapid modifications.

This further object is achieved by a transducer according to claim 8.

Brief Description of the Drawings

The invention is now described in more detail with reference to the enclosed sheets of drawings, given by way of non limiting example, wherein:

figure 1 is a circuit diagram of an inductive transducer according to a preferred embodiment of the invention,

figures 2a, 2b and 2c are graphs that show the trend of some of the voltages at various points of the circuit

CLAIMS

1. A linear inductive transducer (**T**) including
- electric windings (**1-4**) with
  - a primary winding (**1**), and
  - a pair of mutually connected secondary windings (**2,4**),
- a magnetic core (**8**), for performing linear displacements relative to the electric windings,
- a pair of input terminals (**5,6**) electrically connected to said primary winding (**1**) and adapted for being electrically connected to a power supply unit (**C,11,13**),
- at least an output terminal (**7**) electrically connected to said electric windings (**1-4**),

the transducer (**T**) being adapted for providing, through the output terminal (**7**), an electric signal (**Vo**) indicative of the mutual position between said electric windings (**1-4**) and said magnetic core (**8**),
characterized in that the electric windings include a second primary winding (**3**) between said primary winding (**1**) and an input terminal of said pair (**5,6**), the primary windings (**1,3**) being electrically connected to each other and to said pair of secondary windings (**2,4**), said electric signal (**Vo**) including a first (**Vs**) and a second (**Vs'**) component, indicative of the mutual position between said magnetic core (**8**) and said primary windings (**1,3**) and said secondary windings (**2,4**), respectively.

2. The transducer according to claim 1, wherein the primary winding (**1**) and the second primary winding (**3**) are mutually connected in series at a connection point (**9**), the secondary windings (**2,4**) being electrically connected to said connection point (**9**).

3. The transducer according to claim 2, wherein each of said primary winding (**1**) and second primary winding (**3**) provides a signal (**V1,V3**) that is variable as the mutual position between said primary winding (**1**) or second primary

winding (**3**) and said magnetic core (**8**) varies, the first component (**Vs**) of said electric signal (**Vo**) being proportional to the difference between the signals (**V1,V3**) provided by the primary windings (**1,3**).

4. The transducer according to claim 3, wherein the secondary windings (**2,4**) are mutually connected in phase opposition.

5. The transducer according to claim 4, wherein each of said secondary windings (**2,4**) provides an induced signal (**V2,V4**) that is variable as the mutual position between said electric windings (**1-4**) and said magnetic core (**8**) varies, the second component (**Vs'**) of the electric signal (**Vo**) being proportional to the difference between said induced signals (**V2,V4**).

6. The transducer according to one of the preceding claims, wherein said primary winding (**1**) and said second primary winding (**3**) have the same number (**N1**) of turns, and each of said secondary windings (**2,4**) has the same number (**N2**) of turns as the other.

7. The transducer according to one of the preceding claims, wherein said power supply unit includes two sinusoidal voltage generators (**11,13**) connected in phase opposition.

8. A linear inductive transducer (**T'**) including

- electric windings (**21-24**) with
  - a primary winding (**21**), and
  - a pair of mutually connected secondary windings (**22,24**),
- a magnetic core (**28**) for performing linear displacements relative to the electric windings,
- a pair of input terminals (**32,34**) electrically connected to said primary winding (**21**) and adapted for being

electrically connected to a power supply unit

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 :
G01D 5/20

A1

(11) International Publication Number: WO 00/25092

(43) International Publication Date: 4 May 2000 (04.05.00)

(21) International Application Number: PCT/EP99/07957

(22) International Filing Date: 20 October 1999 (20.10.99)

(30) Priority Data:
BO98A000606 26 October 1998 (26.10.98) IT

(71) Applicant *(for all designated States except US)*: MARPOSS SOCIETÀ PER AZIONI [IT/IT]; Via Saliceto, 13, I–40010 Bentivoglio (IT).

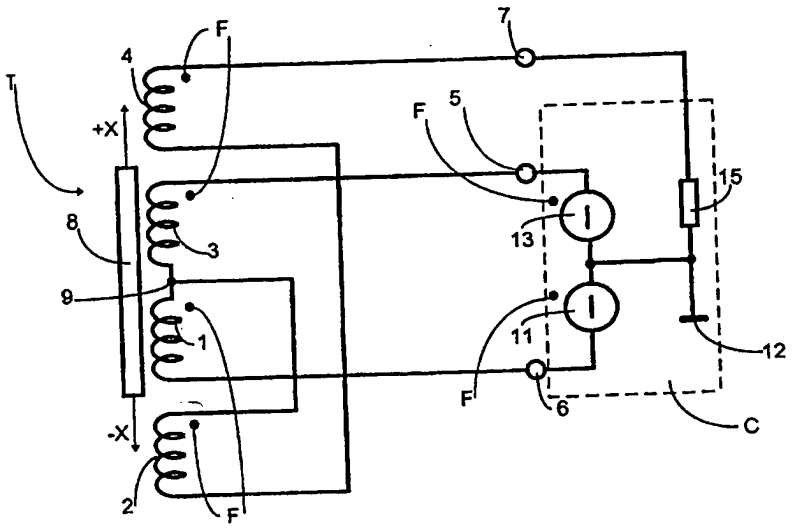
(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: DONDI, Valerio [IT/IT]; Via Don Sturzo, 2, I–40013 Castel Maggiore (IT).

(74) Agent: TAMBURINI, Lucio; Marposs Società per Azioni, Via Saliceto, 13, I–40010 Bentivoglio (IT).

(81) Designated States: JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: LINEAR INDUCTIVE TRANSDUCER



(57) Abstract

A linear inductive transducer (T) includes a pair of primary windings (1, 3), fed by means of a power supply unit (C; 11, 13), a pair of secondary windings (2, 4) and a magnetic core (8), movable with respect to the windings. The secondary windings are electrically connected at an intermediate connection point between the primaries, and the transducer provides an electric output signal (Vo) as the sum of two components (Vs, Vs'), both variable as the mutual position between the windings and the core changes, and that depend on variations of the inductance of the primary windings and mutual inductance between the primaries and the secondaries, respectively. According to a specific configuration, it is also possible, starting from a single structure and by varying, in substance, the power supply and the output connections, to attain a transducer (T') with different functional characteristics (for example, of the differential transformer type, half bridge type, or of another type).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
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LC	Saint Lucia
LI	Liechtenstein
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DESCRIPTION

LINEAR INDUCTIVE TRANSDUCER

Technical Field

The present invention relates to a linear inductive transducer including electric windings with a primary winding and a pair of secondary windings, a magnetic core, for performing linear displacements relative to the electric windings, a pair of input terminals electrically connected to the primary winding and adapted for being electrically connected to a power supply unit, at least an output terminal electrically connected to the electric windings, the transducer being adapted for providing, through the output terminal, an electric signal indicative of the mutual position between the electric windings and the magnetic core.

The invention also relates to a linear inductive transducer including electric windings with a primary winding and a pair of secondary windings, a magnetic core, for performing linear displacements relative to the electric windings, a pair of input terminals electrically connected to the primary winding and adapted for being electrically connected to a power supply unit, and output terminals electrically connected to the electric windings, the transducer being adapted for providing, through at least one of the output terminals, an electric signal indicative of the mutual position between the electric windings and the magnetic core.

Background Art

Transducers with these characteristics, in particular of the Linear Variable Differential Transformer (LVDT) type have been known for a long time and utilized, among other things, in many measuring apparatuses for providing

electric signals indicative of the mutual position between mechanical parts. These transducers include a primary winding and a pair of secondary windings connected together in series opposition. The windings are wound on a substantially cylindrical bobbin at the interior of which a ferromagnetic core displaces along an axial direction. The primary winding is energized with a sinusoidal voltage and generates, at the ends of the secondary windings, induced voltages that vary as the axial position of the core changes. More specifically, the voltages induced in the secondary windings are equal and oppositely phased when the core is at an axially centered position. Thus, the total voltage at the free terminals of the secondary windings is null at said axially centered position, while its amplitude varies as the axial position of the core changes, and its phase changes in response to the sense of the axial displacement with respect to the centered position.

In U.S. Patent No. 4,386,467 there is disclosed a possible application of an LVDT in a comparator for checking a hole of a mechanical piece, in which the core and the transducer windings are respectively coupled to two mutually movable arms that carry feelers for touching diametrically opposite points of the hole.

Other types of inductive transducers are known as Half Bridge Transducers or HBT. These transducers include a pair of series connected windings, wound on a bobbin and energized with a sinusoidal voltage at the free ends thereof, and a ferromagnetic core axially movable within the bobbin. The output voltage is drawn at an intermediate point between the windings and its amplitude varies as the axial position of the core changes. The HBTs are broadly utilized in measuring devices, especially in simple devices like axial, or cartridge, heads, in consideration of the attributes of simplicity and inexpensiveness. Furthermore, unlike the LVDT transducers, the half bridge transducers have low output impedance values (e.g., 300 ohm as compared to 2000 ohm that represent a typical value for an LVDT),

thus the negative effects due to increased load impedance caused by the cable for the connection to the conditioning units are negligible. In fact, different cable lengths determine different load impedance values at the output of the transducer, and said load impedance in turn determines a variation in the amplitude of the output signal that increases the more the transducer output impedance is higher.

In a half bridge transducer the output impedance is relatively low since it is determined by the parallel of the impedances of the two windings, while it is definitely higher in a differential transformer transducer, where it is determined by the sum of the impedances of the two series connected secondary windings.

Another advantageous feature of the HBT in comparison with the LVDT, particularly in multiple applications in which the signals sent by a plurality of transducers have to be managed, is the possibility of utilizing -between each of the HBT and the conditioning unit- one electric connection wire less (three, as compared to four that are necessary for the differential transformer transducers) thereby simplifying the application.

A drawback of the HBTs is the poor sensitivity, i.e. the low ratio between the detected output signal variation and the associated core displacement. In a half bridge transducer, the sensitivity mainly depends on the geometric characteristics, more specifically on the ratio existing between the dimensions of the windings and those of the core, both generally imposed by the dimensions of the measuring device including the transducer. Hence, it is impossible to independently define the sensitivity and modify it for specific applications, for example in an application of a comparator as the one described in the formerly mentioned patent US-A-4,386,467. In fact, in this specific case, as there is an "arms ratio" (i.e., the ratio between the amount of displacement of the feelers and the amount of the associated mutual displacement between the

transducer's core and windings) that is known and generally differs from one, it can be advantageous to define the transducer sensitivity in order to take into account this known ratio, in this way simplifying the processings performed by the conditioning circuit.

Disclosure of Invention

An object of the present invention is to provide a linear inductive transducer that overcomes the disadvantages of the known transducers and, more specifically, enables to define its sensitivity regardless of the geometric characteristics, and none the less ensures a lower output impedance value and a lesser number of external electric connections with respect to the known differential transformer transducers.

This and other objects and advantages are achieved by a transducer according to claim 1.

A further object of the invention is to provide a linear inductive transducer that can present the functional charactersitcs of a differential transformer transducer, or a half bridge transducer, or a transducer of another type, by carrying out simple and rapid modifications.

This further object is achieved by a transducer according to claim 8.

Brief Description of the Drawings

The invention is now described in more detail with reference to the enclosed sheets of drawings, given by way of non limiting example, wherein:

figure 1 is a circuit diagram of an inductive transducer according to a preferred embodiment of the invention,

figures 2a, 2b and 2c are graphs that show the trend of some of the voltages at various points of the circuit

diagram of figure 1, taken at a plurality of mutual positions between the movable parts of the transducer,

figure 3 is a circuit diagram of an inductive transducer according to a different embodiment of the invention and a first possible configuration,

figure 4 is a circuit diagram of the transducer of figure 3, according to a second possible configuration, and

figure 5 is a circuit diagram of the transducer of figure 3, according to a third possible configuration.

The circuit of figure 1 schematically shows an inductive transducer **T** including first and second primary windings **1** and **3**, first and second secondary windings **2** and **4**, two input terminals **5** and **6** and an output terminal **7**. A magnetic core **8** can translate, with respect to windings **1-4**, in the **±X** direction.

A conditioning, or power supply and processing, unit **C** includes two sinusoidal voltage generators **11** and **13**, connected to ground (identified by reference number **12**) and in phase opposition to input terminals **5** and **6**, respectively, while signal processing means, connected to output terminal **7**, are schematically shown with a load impedance **15**.

A connection point **9** intermediate between primary windings **1** and **3** (that have the same number of turns **N1**) is connected to an end of one (**2**) of the secondary windings **2** and **4**, the latter being connected to each other in phase oppostion and having the same number of turns **N2**.

The dots **F** in the figure stand to indicate the phases associated with the voltages across the different windings **1-4** and the voltage generators **11** and **13**.

In an application in a comparator as the one shown in U.S. patent No. 4,386,467, core **8** and windings **1-4** are connected to the two movable arms carrying the feelers, respectively.

The operation of the circuit shown in figure 1 is as follows.

The primary windings **1** and **3** are energized with sinusoidal power supply voltages Va_{11} and Va_{13}, that are identical and in phase oppostion, supplied by generators **11** and **13**.

The voltage **Vo** at output terminal **7**, or measuring signal, is equal to the sum of two components: voltage **Vs**, present -with respect to ground- at intermediate point **9** between primary windings **1** and **3**, and voltage **Vs'** induced in the overall secondary windings **2** and **4**:

$$Vo = Vs + Vs' \quad (1)$$

More particularly, the value of **Vs**, or unbalance voltage of the primary windings, is defined by

$$Vs = (V1 - V3)/2 \quad (2)$$

where **V1** and **V3** indicate the voltages, or potential drops, across the primary windings **1** and **3**, respectively, while the value of **Vs'**, or unbalance voltage of the secondary windings, is defined by

$$Vs' = V4 - V2 \quad (3)$$

where **V4** and **V2** indicate the voltages induced in the secondary windings **4** and **2**, respectively.

When core **8** is at the central, symmetric position with respect to both the primary windings **1** and **3** and the secondary windings **2** and **4** shown in figure 1, both the components of the measuring signal **Vo** become null because the voltages at the ends of each of the primary windings **1** and **3** and each of the secondary windings **2** and **4**, respectively, have identical value:

$$V1 = V3 \quad (4)$$

$$V2 = V4 \quad (5)$$

Thus, in these conditions **Vo = 0**.

The displacement of core **8**, in response, for example, to the mutual displacement of the movable arms of the comparator including the transducer according to the invention, produces a variation in the reluctance of the magnetic circuits of windings **1** and **3**. The consequent inductance variation of the two windings produces two different voltage values **V1** and **V3** and thus an unbalance voltage **Vs** other than zero, according to formula (2).

The displacement of core **8** also varies the mutual inductance between the primary windings altogether considered (**1+3**) and each of the secondary windings **2** and **4**, differentially connected to each other. Therefore, because **V2** ≠ **V4**, unbalance voltage **Vs'** generated in the secondary windings differs from zero, according to formula (3).

The voltages **V2** and **V4** induced in the two secondary windings **2** and **4** by the overall primary winding **1+3** depend -at a specific position of core **8**- on a coupling coefficient **K**. More particularly, making the simplified hypothesis that primary windings **1** and **3** are equal and symmetric with respect to each other, as well as the secondary windings **2** and **4**, then

$$V2 = K \bullet V1 \qquad (6)$$

$$V4 = K \bullet V3 \qquad (7)$$

with

$$K = k \bullet n \qquad (8)$$

where **k** varies depending on the transducer geometric features, and **n** is the turns ratio between secondary and primary windings: **n = N2/N1**.

The above hypothesis foresees the same **k** value in both the formulas (6) and (7) for the sake of simplification and making the substantial aspects of this invention clearer.

When the position of core **8** differs from the central symmetric one of figure 1, by substituting the formulas (2), (3), (6), (7) and (8) in (1), there results:

$$Vo = Vs\ (1 - 2 \bullet k \bullet N2/N1) \qquad (9)$$

Thus, from formula (9) there results that output voltage **Vo** at terminal **7** has a value that, for displacements of core **8** of the same amount, varies among other things as the ratio of the turns varies **n = N2/N1**. As a consequence, contrary to what occurs in the known half bridge transducers, when the application requirements vary, the sensitivity can be set regardless of geometric considerations by choosing the appropriate turns ratio value **n**.

The figures 2a, 2b and 2c show the trend of the voltages hereinbefore mentioned in response to the various positions of core **8**. More specifically, figure 2a refers to the situation shown in figure 1 (core **8** is in a central and symmetric position) while figures 2b and 2c refer to situations according to which core **8** is displaced along **-X** and **+X**, respectively.

The trends of output voltage **Vo** of figures 2b and 2c show that, as the position of core **8** changes, the amplitude of the formerly mentioned voltage **Vo** varies, while the phase indicates the sense (**-X** or **+X**) of displacement of core **8** with respect to the central position of figure 1.

From the foregoing description and the figure 1 illustration, it appears that transducer **T** is connected to conditioning unit **C** by means of three conductors ending at terminals **5**, **6** and **7**, two being necessary for the power supply and one for the transmission of output signal **Vo**.

Another advantage of the transducer shown in figure 1 with respect to the known differential transformer transducers consists in the possibility of obtaining limited output impedance values. In fact, while the impedance value is determined, even in the arrangement shown in figure 1, by the sum of the impedances of the two secondary windings **2** and **4**, in this case it is possible to choose a small number of turns **N2** (and consequently low impedance values of the secondary windings **2** and **4**) without causing -contrary to what occurs in the LVDTs- an unacceptable decrease in the transducer sensitivity. In fact, in the transducer according to the present invention, output signal **Vo** does not only depend on the transformer coupling, but, according to formula (1), it is the sum of two components. Thus, the choice of the appropriate turns ratio **n** (formula (9)) enables to achieve -in an extremely flexible way- the best possible balance among the required sensitivity and output impedance values.

According to an alternative to the herein illustrated and so far described embodiment, the primary windings **1** and **3**

are energized with a single sinusoidal voltage between terminals **5** and **6**, instead of the phase opposition voltages Va_{11} and Va_{13}. In this case, voltage **Vs** -at the center position of core **8**- has a known amplitude value that differs from zero (for example, equal to half that of the energizing voltage). With respect to the previously described embodiment, this alternative does not present substantial differences, apart from the phase of output voltage **Vo**, that does not enable to immediately distinguish displacements in one or in the other sense with respect to the central position of core **8**.

The transducer **T'** shown in figures 3, 4 and 5 includes first and second primary windings **21** and **23** connected in series at a connection point **29**, first and second secondary windings **22** and **24**, five terminals **31**, **32**, **33**, **34** and **35** and a magnetic core **28** that can perform translation displacements with respect to windings **21-24**.

In the configuration shown in figure 3, transducer **T'** is substantially similar to transducer **T** of figure 1. In fact, in this configuration, terminal **33** (that ends at connection point **29**) and terminal **35** are short circuited, for example by means of a wire **36**. The voltage generators **11** and **13** of the conditioning unit **C**, shown in figure 1, are connected to terminals **32** and **34**, while output voltage **Vo** - substantially identical to the one attained with transducer **T**- is detected at the ends of load impedance **15** between terminal **31** and ground **12**.

In the configuration shown in figure 4, secondary windings **22** and **24**, ending at terminals **31** and **35**, are not connected to external units and thus are insulated. By providing in this configuration, too, a connection between voltage generators **11** and **13** and terminals **32** and **34**, it is possible to attain, by utilizing a suitable setting resistor **27**, an output voltage **Vo'** -at the ends of a load impedance **15'** between terminal **33** and ground **12**- that varies as the position of core **28** changes, according to the

well known functioning principle of a half bridge transducer or HBT.

Furthermore, in the configuration shown in figure 5, terminal **33** is insulated. A sinusoidal voltage generator **11'** is connected to terminals **32** and **34** for feeding a primary winding **21+23** that consists of both windings **21** and **23**, while an output voltage **Vo''** is detected, by utilizing a suitable setting resistor **30**, at the ends of a load impedance **15''** between terminals **31** and **35** (the latter being connected to ground **12**). Voltage **Vo''** varies as the position of core **28** changes, according to the well known functioning principle of a linear variable differential transformer or LVDT.

From the concise description of figures 3, 4 and 5, it appears that transducer **T'** is particularly flexible, since with a single structure it is possible to attain transducers of different types (LVDT, HBT or transducers of the new type described with reference to figure 1), and in each case achieve the type of transducer with the characteristics that best suit the specific application.

It is also to be noted that the setting resistors **27** and **30** are connected, respectively, to terminal **33** (insulated in the configuration of figure 5) and between terminals **31** and **35** (insulated in the configuration of figure 4). This enables to independently set the sensitivity for the HBT configuration (shown in figure 4) and LVDT configuration (shown in figure 5) on the same transducer **T'** and directly choose the proper configuration in the application phase, without the need of a further setting.

Transducers that include modifications with respect to what is herein schematically illustrated and so far described, for example in connection with the relative phases of the voltages at the ends of the different windings, also fall within the scope of this invention. In particular, by inverting the phase of the secondary windings (**2** and **4** shown in figure 1) with respect to that of the primary windings (**1** and **3**), formula (2) changes to **Vs = (V1 - V3)/2**

and, as a consequence, formula (9) changes to **Vo = Vs (1 + 2 • k • N2/N1)**. Thus, this alternative choice enables to attain a higher sensitivity.

As previously discussed with reference to the known transducers (of the LVDT or the HBT type), the use of the linear inductive transducers in measuring and control devices and apparatuses is quite widespread and varied, and the comparator shown in the herein mentioned patent US-A-4,386,467 represents just one of the many possible applications for transducers **T** and **T'** according to the present invention.

CLAIMS

1. A linear inductive transducer (**T**) including
- electric windings (**1-4**) with
  - a primary winding (**1**), and
  - a pair of secondary windings (**2,4**),
- a magnetic core (**8**), for performing linear displacements relative to the electric windings,
- a pair of input terminals (**5,6**) electrically connected to said primary winding (**1**) and adapted for being electrically connected to a power supply unit (**C,11,13**),
- at least an output terminal (**7**) electrically connected to said electric windings (**1-4**),

the transducer (**T**) being adapted for providing, through the output terminal (**7**), an electric signal (**Vo**) indicative of the mutual position between said electric windings (**1-4**) and said magnetic core (**8**),
characterized in that the electric windings include a second primary winding (**3**) between said primary winding (**1**) and an input terminal of said pair (**5,6**), the primary windings (**1,3**) being electrically connected to each other and to said pair of secondary windings (**2,4**), said electric signal (**Vo**) including a first (**Vs**) and a second (**Vs'**) component, indicative of the mutual position between the magnetic core (**8**) and said primary windings (**1,3**) and said secondary windings (**2,4**), respectively.

2. The transducer according to claim 1, wherein the primary winding (**1**) and the second primary winding (**3**) are mutually connected in series at a connection point (**9**), the secondary windings (**2,4**) being electrically connected to said connection point (**9**).

3. The transducer according to claim 2, wherein each of said primary winding (**1**) and second primary winding (**3**) provides a signal (**V1,V3**) that is variable as the mutual position between said primary winding (**1**) or second primary

winding (3) and said magnetic core (8) varies, the first component (**Vs**) of said electric signal (**Vo**) being proportional to the difference between the signals (**V1,V3**) provided by the primary windings (**1,3**).

4. The transducer according to claim 3, wherein the secondary windings (**2,4**) are mutually connected in phase opposition.

5. The transducer according to claim 4, wherein each of said secondary windings (**2,4**) provides an induced signal (**V2,V4**) that is variable as the mutual position between said electric windings (**1-4**) and said magnetic core (**8**) varies, the second component (**Vs'**) of the electric signal (**Vo**) being proportional to the difference between said induced signals (**V2,V4**).

6. The transducer according to one of the preceding claims, wherein said primary winding (**1**) and said second primary winding (**3**) have the same number (**N1**) of turns, and each of said secondary windings (**2,4**) has the same number (**N2**) of turns as the other.

7. The transducer according to one of the preceding claims, wherein said power supply unit includes two sinusoidal voltage generators (**11,13**) connected in phase opposition.

8. A linear inductive transducer (**T'**) including

- electric windings (**21-24**) with
  - a primary winding (**21**), and
  - a pair of secondary windings (**22,24**),
- a magnetic core (**28**) for performing linear displacements relative to the electric windings,
- a pair of input terminals (**32,34**) electrically connected to said primary winding (**21**) and adapted for being electrically connected to a power supply unit

(11,13;11'), and

- output terminals (31,33,35) electrically connected to said electric windings (21-24),

the transducer (T') being adapted for providing, at at least one of said output terminals (31,33,35), an electric signal (Vo;Vo';Vo'') indicative of the mutual position between said electric windings (21-24) and said magnetic core (8),

characterized in that the electric windings include a second primary winding (23) between said primary winding (21) and an input terminal of said pair (32,34), the primary (21) and the second primary (23) windings being mutually connected in series at a connection point (29),

said output terminals include three output terminals (31,33,35) electrically connected to the ends of said pair of secondary windings (22,24) and to said connection point (29) between the primary windings (21,23),

the transducer (T') being adapted for selectively providing said electric signal (Vo;Vo';Vo'') at one (31;33) or a pair (31,35) of said three output terminals (31,33,35).

9. The transducer according to claim 8, wherein the secondary windings (22,24) are mutually connected in phase opposition.

10. The transducer according to claim 8 or claim 9, wherein two (33,35) of said three output terminals (31,33,35) are adapted for being electrically connected to one another for achieving an electric connection between the primary windings (21,23) and the secondary windings (22,24), the transducer (T') being adapted for providing said electric signal (Vo) at the other (31) of said three output terminals (31,33,35).

11. The transducer according to claim 10, wherein said electric signal (Vo) includes a first (Vs) and a second (Vs') component, indicative of the mutual position between

the magnetic core (**28**) and the primary windings (**21,23**) and, respectively, the secondary windings (**22,24**).

12. The transducer according to claim 8 or claim 9, wherein two (**31,35**) of said three output terminals (**31,33,35**) are adapted for being insulated, the transducer (**T'**) being adapted for providing said electric signal (**Vo'**) at the other (**33**) of said three output terminals (**31,33,35**).

13. The transducer according to one of claims from 8 to 12, wherein said power supply unit includes two sinusoidal voltage generators (**11,13**) connected in phase opposition.

14. The transducer according to claim 8 or claim 9, wherein the output terminal (**33**) connected to the connection point (**29**) is adapted for being insulated, the transducer (**T'**) being adapted for providing said electric signal (**Vo''**) at the two output terminals (**31,35**) at the ends of said pair of secondary windings (**22,24**).

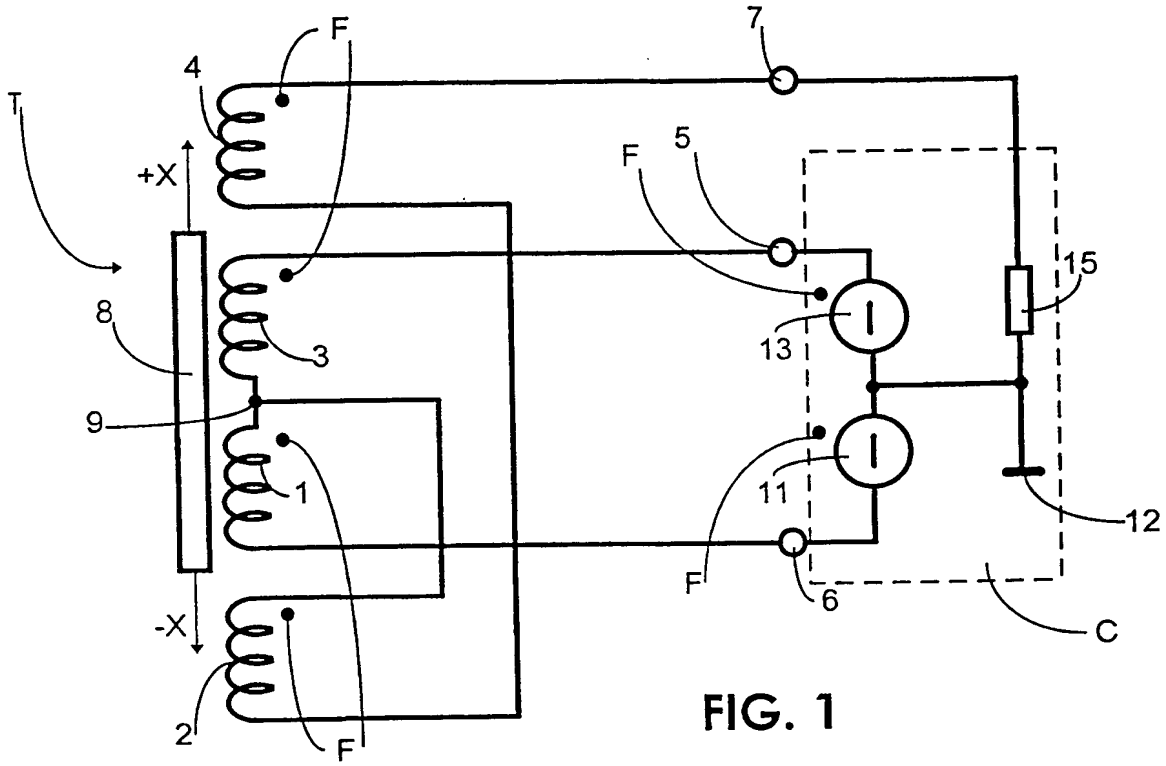
T
F
4
+X
8
9
3
1
-X
2
F
7
F
5
13
11
F
6
15
12
C

FIG. 1

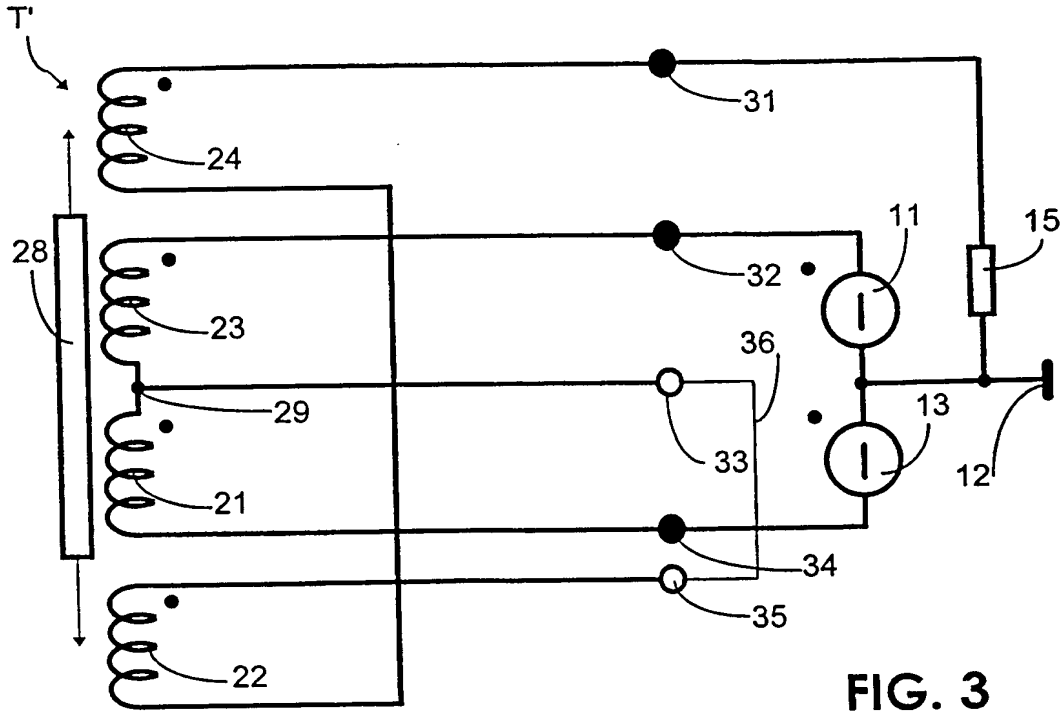
T'
24
28
23
29
21
22
31
32
36
33
34
35
11
15
13
12

FIG. 3

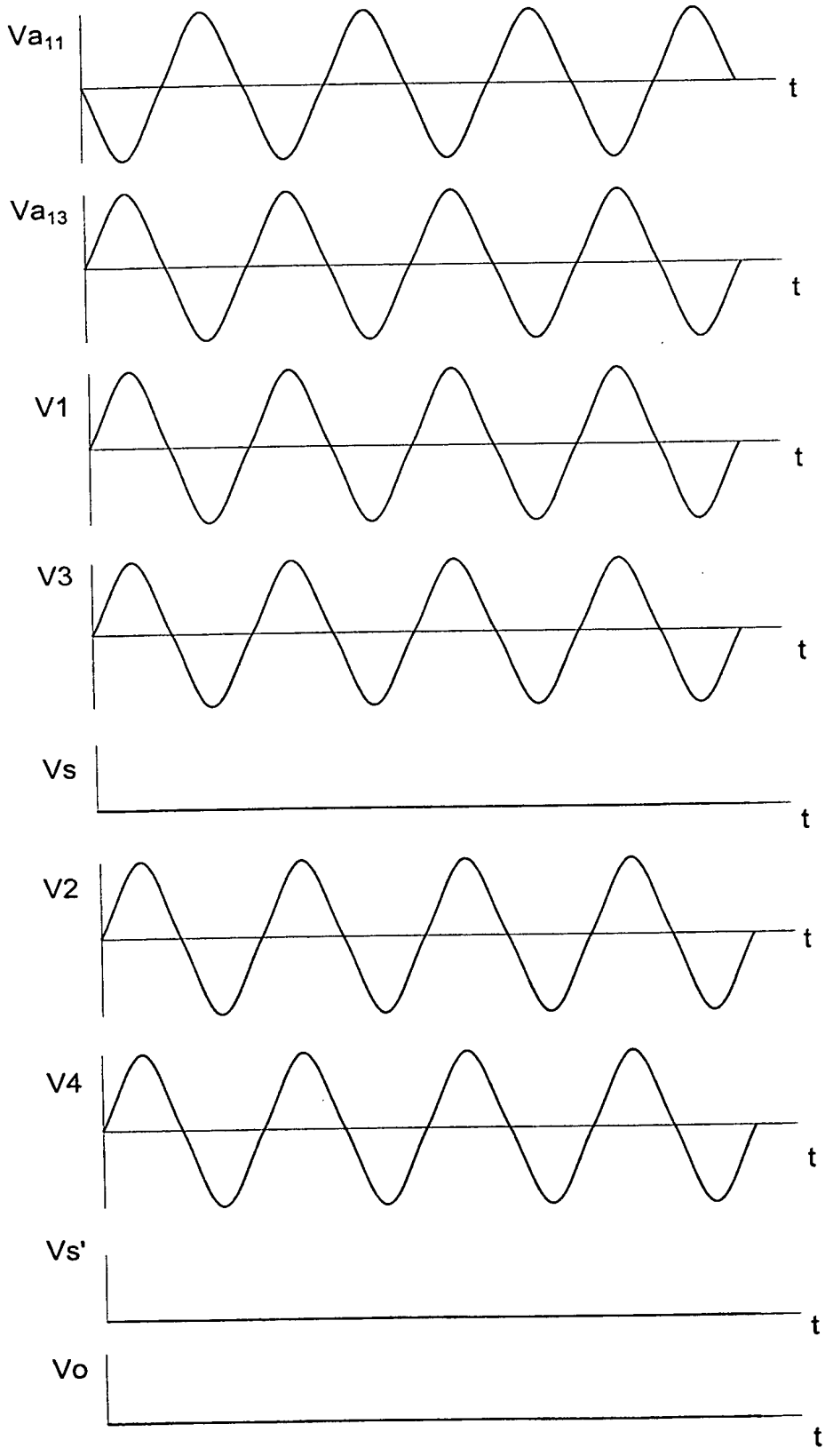

FIG. 2a

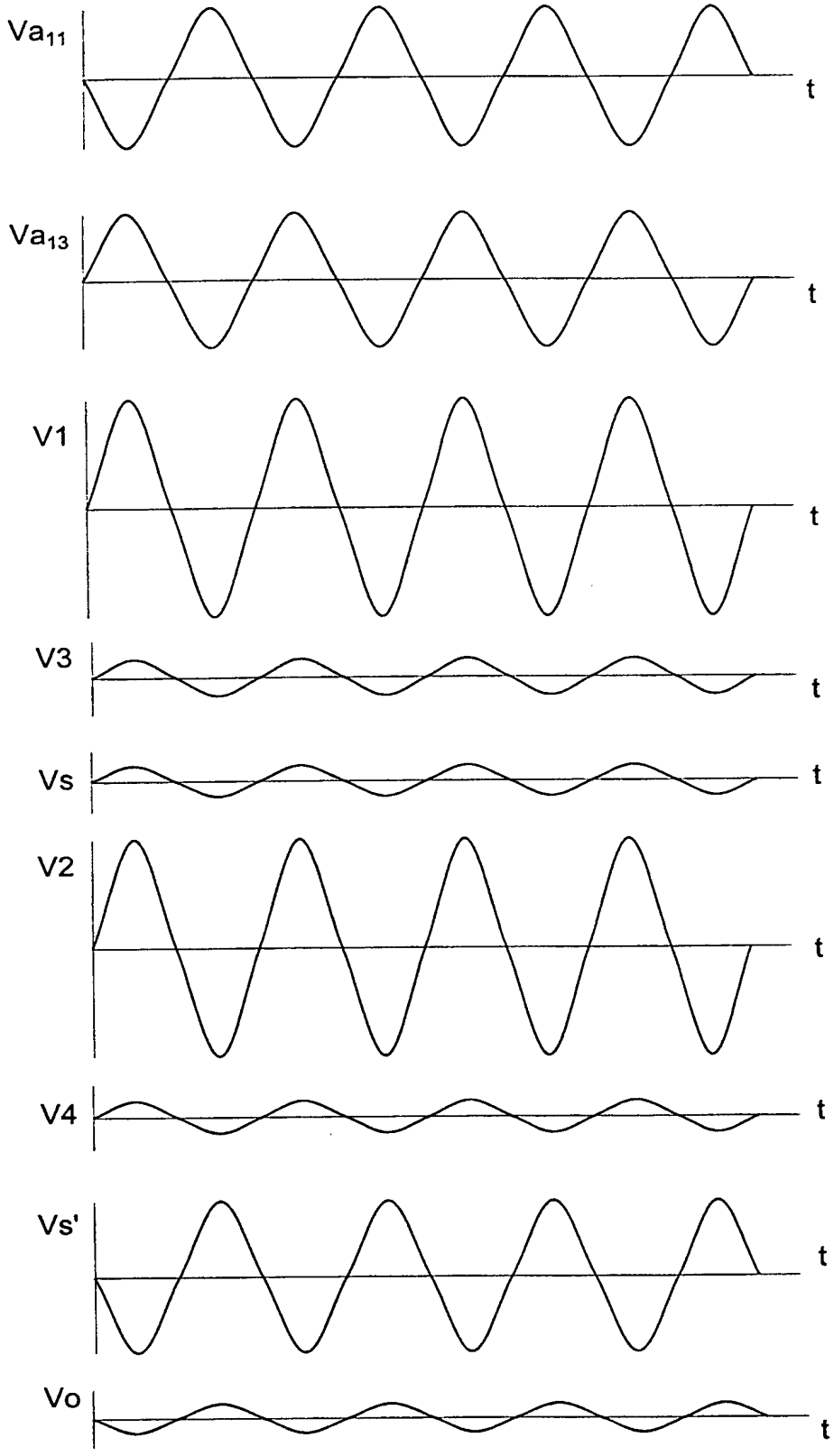

FIG. 2b

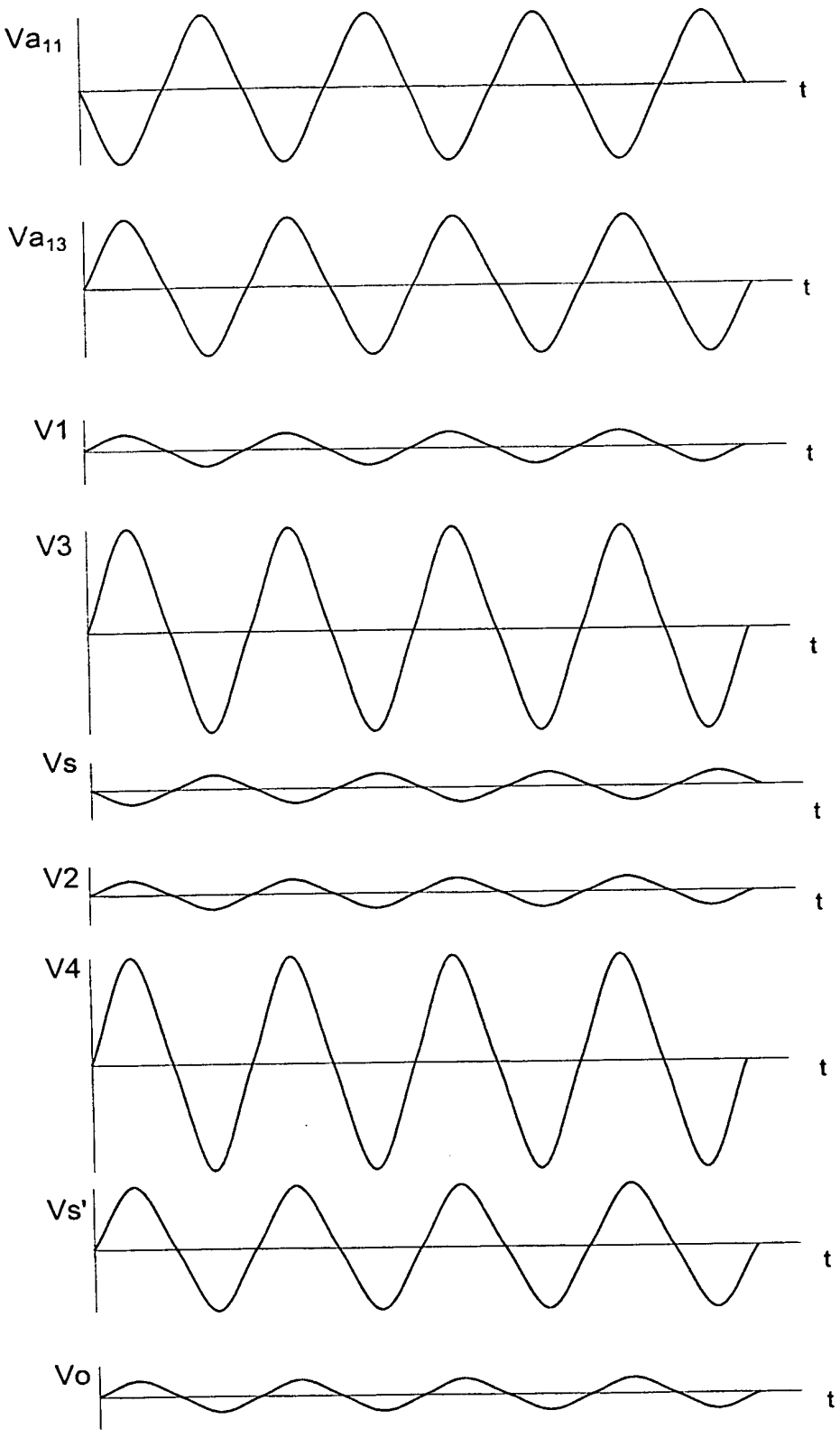

FIG. 2c

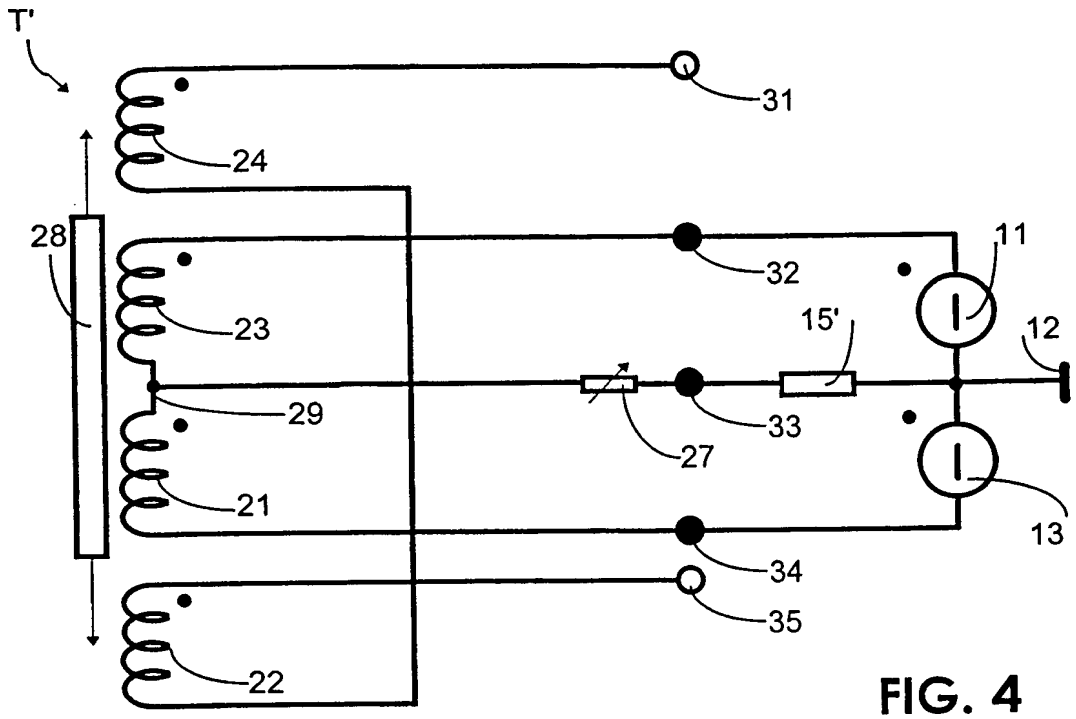
T'
31
24
28
32
11
23
15'
12
29
33
27
21
13
34
35
22

FIG. 4

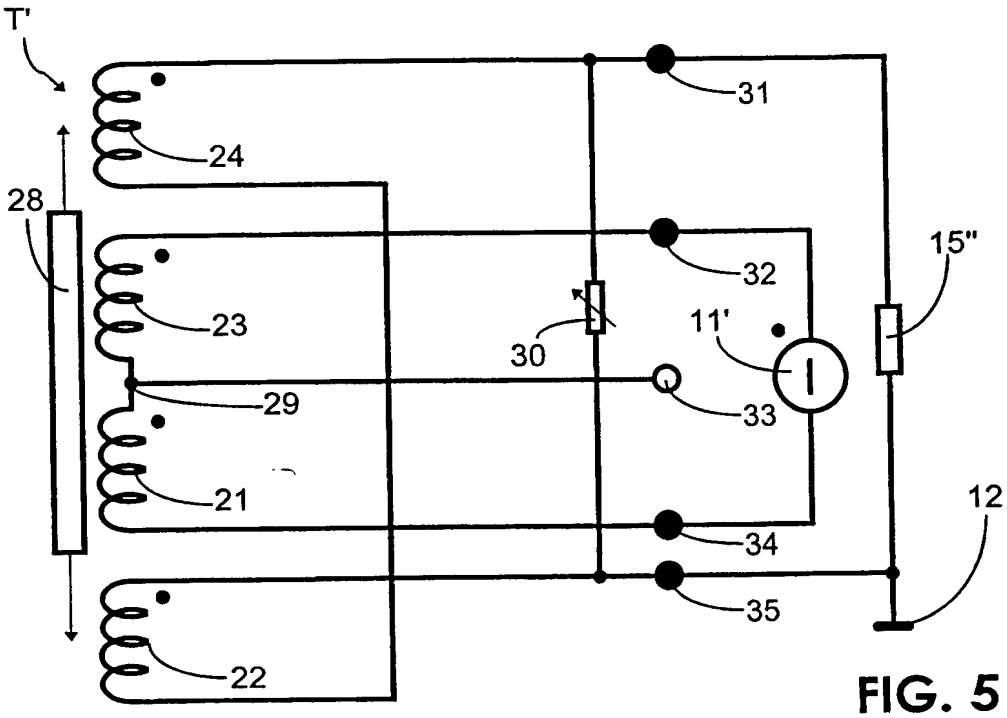
T'
31
24
28
32
15"
23
30
11'
29
33
21
12
34
35
22

FIG. 5

INTERNATIONAL SEARCH REPORT

Interr. Application No
PCT/EP 99/07957

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01D5/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 678 991 A (SCHMIDT SAMUEL) 7 July 1987 (1987-07-07) column 3, line 30 -column 4, line 63; figures 1,2	1,2
A		4,6,8,9

Y	GB 1 433 402 A (HORE D L) 28 April 1976 (1976-04-28) page 3, line 16 - line 61; figure 5C	1,2
A		4,6,8,9

A	FR 2 466 620 A (BOSCH GMBH ROBERT) 10 April 1981 (1981-04-10) the whole document	1,8

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 February 2000	09/02/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Chapple, I

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern[redacted] Application No
PCT/EP 99/07957

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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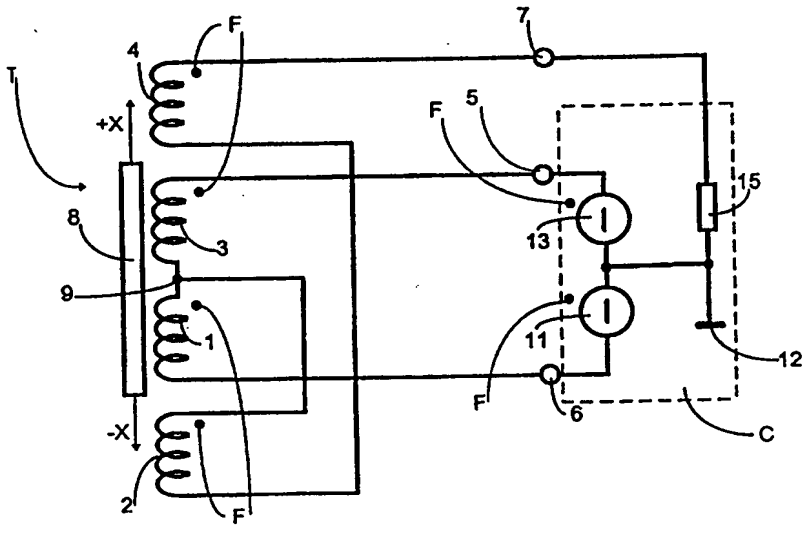

(57) Abstract

A linear inductive transducer (T) includes a pair of primary windings (1, 3), fed by means of a power supply unit (C; 11, 13), a pair of secondary windings (2, 4) and a magnetic core (8), movable with respect to the windings. The secondary windings are electrically connected at an intermediate connection point between the primaries, and the transducer provides an electric output signal (Vo) as the sum of two components (Vs, Vs'), both variable as the mutual position between the windings and the core changes, and that depend on variations of the inductance of the primary windings and mutual inductance between the primaries and the secondaries, respectively. According to a specific configuration, it is also possible, starting from a single structure and by varying, in substance, the power supply and the output connections, to attain a transducer (T') with different functional characteristics (for example, of the differential transformer type, half bridge type, or of another type).

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A. CLASSIFICATION OF SUBJECT MAT...
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 678 991 A (SCHMIDT SAMUEL) 7 July 1987 (1987-07-07) column 3, line 30 -column 4, line 63; figures 1,2	1,2
A		4,6,8,9
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A		4,6,8,9
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